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ABSTRACT

This study examined both district-level and teacher-level considerations in the implementation of standards-based middle school mathematics curriculum. In particular, the following questions were addressed: (1) What district-level constraints and considerations impact decisions regarding implementation of a standards-based middle school mathematics curriculum? and (2) How do individual teachers within a district respond to the decision to implement standards-based middle school mathematics curriculum, to what extent is their implementation faithful to the philosophy of the standards-based curriculum, and why and in what ways has their instruction changed as a result of this implementation? A two-tier case study design was used to examine the district- and classroom-level issues related to full implementation of standards-based mathematics curriculum. Two districts that underwent recent curriculum change were chosen as district case study sites. Within each district, three teachers were selected as case studies. Each teacher was teaching from the standards-based curriculum but had varying degrees of professional development and prior experience with the curriculum. It was concluded that implementing standards-based mathematics curriculum throughout a system is a complex process. The existence of a standards-based text supports teachers who want to and know how to implement standards-based practices, facilitating their efforts to change their teaching. The texts alone, however, do not result in different teaching capable of being adapted to more traditional practices. Regardless of teachers' instructional practices, new curricula do, by their existence, solicit attention from stakeholders in the community. (Contains 20 references.) (ASK)

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The Dynamics of Implementing and Sustaining Standards-based Mathematics Curricula in Middle Schools

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The Dynamics of Implementing and Sustaining Standards-based Mathematics Curricula in Middle Schools

The middle school mathematics curriculum in the United States has been characterized as repetitious, addressing many topics superficially, and focused on skill acquisition (Flanders, 1987; Stigler & Hiebert, 1997). Many reports have alerted Americans to the deficits in children's learning of mathematics including *A Nation at Risk* (National Commission on Excellence in Education, 1983), which decried the status of the American educational system. Deficits in both curriculum and student learning have been articulated in national and international assessments, such as the National Assessment of Educational Progress (NAEP) (Silver, 1997) and the Third International Mathematics and Science Study (TIMSS) (Beaton, Mullis, Gonzalez E. J., Kelly, Smith, 1996). These documents attribute weaknesses in student knowledge in part to a substandard U.S. mathematics curriculum.

Recommendations for developing a better curriculum and for improving instruction have been articulated by NCTM in a number of publications including the *Agenda for Action*, *The Curriculum and Evaluation Standards*, and the *Teaching Standards* (NCTM, 1980, 1989, 1991). These documents described a curriculum that is challenging, engaging, and that leads to increased understanding of mathematical concepts and procedures. Each of the publications articulated common views on the essentials for an improved mathematics curriculum. Problem solving, communication, and reasoning

processes that enhance students learning of mathematics should be found throughout the curriculum. A mathematics curriculum must provide more mathematics and deeper investigation of the mathematical topics (e.g., algebra and geometry) to be learned. In addition, a variety of assessment tools should be used to more accurately gauge the progress of students' learning.

Standards-based Curriculum

In response to the demand for better mathematics curriculum, the National Science Foundation (NSF) funded the development of comprehensive mathematics curricula for grades K through 12 that align with the NCTM *Standards* (1989, 1991, 1995). The resulting five middle school curricula focus on conceptual development, integrating content within mathematics, connecting mathematics to appropriate contexts and applications for middle school students, and incorporating mathematical reasoning and problem solving.

The mathematics content includes appropriate attention to algebra, number, geometry, and data and probability. In addition, the curricula are designed to engage students through discovering mathematical relationships, applying their own strategies in problem solving situations, and for communicating about the processes they used in solving problems. Standards-based curricula encourage students to develop an understanding and appreciation of the important role of mathematics in scientific applications and as an interesting field of study (Reys, Robinson, Sconiers, & Mark

1999). In standards-based curriculum, conceptual development as well as skill development is valued and there are opportunities for students to "explore, conjecture, to reason logically and to use a variety of mathematical methods to solve problems" (Reys et al., 1999, p. 454).

Research related to Standards-based Mathematics

In addition to having curricula that support the vision of the *Standards* documents, it is well documented that if teachers are to incorporate the instructional strategies outlined in the *Standards*, they need personal support during the process of pedagogical change as well as professional development (NCTM, 1991; Wood, Cobb, & Yackel, 1991; Cohen & Hill, 1998). An initial and valuable way to support teachers is to have a curriculum that is aligned with their instructional goals. Studies have shown that the most important factor in determining what a teacher teaches is the textbook (Willoughby, 1990). A textbook, while supportive, is not sufficient to enable teachers to change their practices (Remillard, 1992; Heaton, 1992), however, professional development combined with a supportive text has been found to be effective in promoting change in teaching practices (Cohen & Hill, 1998; Cohen & Hickman, 1998).

Combining professional development with orientation to curricula that support standards-based mathematics practices was the purpose of the Missouri Middle-grades Mathematics (M³) Project. This 3-year professional development project, funded by the National Science Foundation, involved 22 districts in Missouri and about 165 teachers. In

several districts, the exposure to the curricula and the philosophy of standards-based mathematics resulted in the full implementation of a NSF-funded, standards-based mathematics curriculum.

Successful district-wide adoption of a comprehensive standards-based curriculum depends on several factors. First, teachers play a critical role. Their belief and confidence in the curricula, as well as the support they receive as they implement a curriculum, determine the extent and nature of the implementation outcomes. Second, the support of district administration and parents is critical. In addition, districts have unique issues based on the local community, their previous experiences, and the personalities of the teachers. As Dewey wrote over 60 years ago, "Experience does not occur in a vacuum. There are sources outside an individual which give rise to experience" (Dewey, 1938, p. 40). To understand factors influencing curricular change, one must take a comprehensive approach by looking at the teachers, administrators, and parents. Teachers within the district influence and are influenced by both the culture of the community and the culture of the school and by the process which initiates and supports curriculum implementation. The decisions teachers make in handling district-level issues and classroom practices define their own classroom implementation which ultimately impacts the district implementation and the learning experiences of the students in the district.

The study reported here considered both district-level and teacher-level considerations in the implementation of standards-based middle school mathematics curriculum. In particular it addressed the following questions:

1. What district-level constraints and considerations impact decisions regarding implementation of a standards-based middle school mathematics curriculum?

2. How do individual teachers within a district respond to the decision to implement standards-based middle school mathematics curriculum? What instructional decisions do they make? To what extent is their implementation faithful to the philosophy of the standards-based curriculum? Why and in what ways has their instruction changed as a result of this implementation?

Methodology

A two-tier case study design was used to examine the district-level and classroom-level issues related to full implementation of standards-based mathematics curriculum. Two districts that had undergone recent curriculum change, Galesburg and Brooksdale, were chosen as district case study sites. Within each district, three teachers were selected as teacher case studies. Each teacher was teaching from the standards-based curriculum, but had varying degrees of professional development and prior experience with the curriculum.

Data collected to inform and evaluate the M³ Project, interview data, and classroom observations provided baseline data from which to study the district-level and

teacher-level considerations in implementation of standards-based middle school mathematics curriculum. Data collected to study the district-level considerations included pre- and post- survey data, individual reflections, and district team reflections from all 17 teachers within the two districts who had participated in the M³ Project. For individual teacher cases, three 3-day observations were completed over a four month span. These observations were audio-recorded and transcribed. During each visit, interviews were conducted with each teacher.

Galesburg School District

Located in a rural part of its state, this city of 10,000 people has two schools for middle grade students, a 6th grade school and a junior high (grades 7 - 9). Together these two schools house a total of 900 middle school students (gr. 6-8) taught by 10 mathematics teachers. At the start to the M³ Project, three members of the district joined the project, a 6th grade teacher, a 7th grade teacher, and the computer specialist for the district who served as the administrator. In the second year, the rest of the teachers joined the project, however, not all of the teachers attended all conferences. In the second year of the M³ Project, Galesburg selected *MATH Themes* in its pilot version, for use of all students in grades 6 and 7. In 1998-1999, Galesburg began using the final version of *MATH Themes* in grades 6 and 7 and began to use *MATH Themes* in 8th grade with all but the top 20% of students that took a traditional algebra course.

During the third year of full implementation, the year the study was conducted, ten teachers were teaching *MATH Thematics*, though not all of those teachers taught from it all three years. In fact, three teachers were new to the curriculum, the district, and to teaching.

Brooksdale School District

Brooksdale is a small suburb of a large city. Parents of the students in this district were upper-middle class and were reportedly highly involved in their child's education. Brooksdale also educated a population of students that were bussed from the inner city. The school had teams of teachers sharing the same students, with time built into the school day for teachers to collaborate with other members of their team.

Four teachers from Brooksdale School District joined the M³ Project in December of the first year (1995). In addition a 5th teacher did not participate in the project, but did participate in the piloting and selection. She had attended a summer institute in which she had received training for *Connected Mathematics Project* (CMP). She did join the M³ Project in the second year. Brooksdale teachers were encouraged to attend professional development activities and received funding to do so. Four teachers began implementing CMP in the 6th and 7th grades in the 1996-97 school year with all but the advanced students (top 10-15%).

The 1998-1999 school year marked the third year of implementation for grades 6 and 7 and the first year for 8th grade. Sixth grade was using exclusively CMP, seventh

grade was using it exclusively in their regular classes and as a supplement to the advanced class (pre-algebra). All 8th grade mathematics classes were algebra. In 1998-1999, teachers began using only CMP in all the regular algebra classes (75% of students) and using parts of CMP in the advanced algebra class.

District-level Issues of Implementation and Sustainability

There were common constraints and considerations related to the implementation of standards-based middle school mathematics curriculum in both Galesburg and Brooksdale. There were also differences between the districts' decision-making process and the extent of teacher involvement in selecting and using the curricula. These commonalities and distinctions had an impact on the nature of the implementation in each district.

Participation and Leadership

The leadership and the level of involvement of teachers using the curriculum had an impact on district implementation. Galesburg and Brooksdale both implemented a standards-based curriculum primarily at the prompting of teacher leaders within the district, although the form of leadership varied in the two districts. In Galesburg, one teacher emerged as the driving force behind the process of changing the mathematics curriculum. She played a critical role in supporting other 7th grade teachers who were involved in the first year of implementation and in building support at the junior high.

Brooksdale, in contrast, did not have a particular leader; all of the 6th and 7th grade teachers played a leadership role in selecting and implementing the curriculum.

The leadership comparison is important because those people in leadership roles in both districts felt strongly that the new curriculum was a success, but those not in leadership roles were not as convinced. In the case of Brooksdale, where all teachers were involved in the process, all teachers described themselves as better teachers and teaching better mathematics. In Galesburg, teachers involved in the original selection were strong supporters of the curriculum, but those teachers not involved in the process reported being frustrated and discontent with the curriculum. This is consistent with teacher empowerment research that reports the need to involve teachers in all stages of implementation (Simon & Schifter, 1996; Smylie, 1996; Rice, 1995).

Collaboration

Teacher collaboration became important in the decision-making in the district. In the case of Brooksdale, where all teachers were involved throughout the process, meetings for the whole middle school faculty and for the grade-level pairs were considered to be valuable and necessary. Even in the third year of implementation, collaboration was commonplace in the school. The dialogue among teachers continued to influence teachers' perceptions and practices as they continued to reflect and adapt. In Galesburg, the different levels of involvement in the change process was an impediment to collaboration. These teachers did not find it valuable to meet and when the principal quit requiring

meetings, the meetings ended. In 7th grade teachers collaborated extensively during the first year, but in later years, with teacher turnover, the collaboration diminished significantly.

Worthwhile collaborative relationships were difficult to establish and difficult to maintain. Two issues warrant attention regarding collaboration. First, teachers that joined the process of implementation at different stages collaborated significantly less than those that had a shared history with the selection and implementation process. They were not able to establish a meaningful collaboration with all teachers. Secondly, teacher turnover resulted in the dissolution of collaborative relationships. Teachers were not able to re-create these collaborations when new teachers arrived.

Parental Influence

In both districts teachers were aware of the strong influence parents have on school decisions. They differed, however, on what the perceived desires of parents were and how that should be handled. In Galesburg, teachers viewed parents as resistant to change. There was no attempt to educate parents until parents became vocal about the atypical homework they were seeing. To meet the perceived needs of parents, time was given during class to do all or most of the problems. This decision decreased the amount of curriculum that was covered. In the 6th grade to avoid parent problems, teachers sent home skill practice worksheets. Brooksdale parents were concerned with the curriculum that was in place prior to CMP. The principal had reported that many parents

complained the mathematics curriculum wasn't challenging enough for their children. As Brooksdale teachers searched for a new curriculum, the parents' desire for a more challenging curriculum was a consideration during the selection process. Once the CMP curriculum was chosen, teachers had several parent night sessions in which they promoted how challenging the curriculum was and the high level of mathematics that was imbedded in the curriculum. Brooksdale teachers offered opportunities for students to get help, but did not supplement the curriculum, except on rare occasions.

It is important to note three things. First, in one district the parents were content with the previous curriculum and in the other district they were not. Second, in one district, the parents were in very different types of jobs than the later. One Galesburg teacher commented that parents in her district don't see the purpose of collaboration or problem solving because their jobs don't involve much of this. Finally, the timing of when parents were included in on the implementation process differed in the two sites, one being proactive and the other retroactive.

Students' Needs

Related to, and perhaps overlapping with, parent expectations were the expectations teachers had for their students. In both districts, the selection of the curriculum was based on the perceived needs of the students. In Galesburg, teachers made their selection, "based not on which curriculum was best, but on which curriculum was best for [their] students." What this meant for this district was finding a curriculum

that wasn't too hard for their students but prepared them for state assessments.

Similarly, several teachers in Brooksdale and the principal explicitly stated the need to find the curriculum that was best for their students, however, in Brooksdale this meant finding a curriculum that was more challenging.

Expectations of students also impacted the way each curriculum was used in classrooms. In Brooksdale, teachers felt the level of difficulty and the focus on concepts was appropriate and therefore they did little to supplement the curriculum. Galesburg teachers felt that students needed more skill practice, so more supplementing with worksheets was evidenced. In addition, the amount of instruction students in Brooksdale received prior to and during investigations was considerably less than the assistance they received in Galesburg.

Accountability

Outside assessments such as state and national tests, have a strong influence in driving curriculum. State and national test results were of primary interest in both districts. After the first year of implementation, teachers and administrators used the higher district averages on state test scores to argue that the new curriculum was better than the previous curriculum. Test scores in both districts were reported to influence parents' view of the curriculum. This was stated much more strongly in Brooksdale where several teachers reported that the bottom line with parents was student achievement on standardized tests.

In Galesburg the state assessment took on a role that it did not in Brooksdale. Many teachers cited the new state assessment as a main reason for adopting *MATH* *Thematics*. In both districts, then, assessment served to evaluate the effectiveness of the program, while in Galesburg it also served as a change agent.

Algebra in Eighth Grade

As teachers in both districts made decisions about implementing a standards-based curriculum, the issue of Algebra was another district level consideration. In fact, both districts decided that it would be too difficult to include eighth grade in the original implementation due to the expectations of the community and the administration that at least some (and in Brooksdale, all) students take algebra in the eighth grade. The reported reason in both districts for adding eighth grade to the implementation was due to the success the sixth and seventh graders were having on standardized tests (the Stanford Achievement Test and an algebra readiness test). The eighth grade implementation, however, was still not for all students. In Galesburg, the approximately 20% that were in algebra were in a different text and in Brooksdale, the top 25% that were in the advanced course were in a different text.

Implementing standards-based curriculum in eighth grade required additional effort on the part of the teachers. First, they had to assure parents that students were still learning algebraic concepts. In Brooksdale, this meant supplementing CMP with some traditional algebra. In Galesburg, the eighth grade teachers were struggling with including

the parts of the curriculum that were not algebra-related. In both schools it meant titling the course as an algebra or pre-algebra course.

Teacher-level Issues of Implementation and Sustainability

Teachers in Galesburg and Brooksdale responded to the districts' decision to implement standard-based mathematics curriculum in different ways. Some similarities were found across districts, some similarities in teacher responses were unique within a district, and still other practices were strictly individualistic. In particular, the nature and extent the curriculum was implemented and related instructional strategies employed varied in both districts. The experiences that teachers had prior to and during implementation influenced their implementation of the curriculum in the classroom. Finally, the desire to balance skill and concept development was prevalent across districts and influenced the nature and extent of implementation. While teachers' own perceptions and personal history factored into their teaching practices, the district-level implementation process also influenced their teaching.

Decision-making and Collaboration

Decision-making and ongoing teacher collaboration influenced each other and had a significant impact on classroom teaching. Decision-making and collaboration appeared to be interrelated: in making decisions as a group, teachers created a shared vision, which in turn built a mutually beneficial relationship that motivated teachers to continue to work

with their colleagues, leading to more shared decision-making and collaboration. In collaborating to make the initial district-level decision to implement, the teachers learned how to interact with each other and learned what they could gain from each other at the classroom level. For example, two Brooksdale teachers reported that they were concerned about being paired to work together knowing they had different approaches to teaching, however, their initial collaboration resulted in both valuing the strengths of the other teacher. Conversely, in Galesburg, the 6th grade teachers described themselves as "different types of teachers" and eschewed collaborative planning and decision-making, and no collaborative relationships were built or strengthened.

When the initial process did not involve all implementers, it was less likely that teachers maintained communication during classroom implementation. The need to collaborate is well documented as a major concern for teachers in reform (Bay et al., 1999; Ball, 1996b; Shanker, 1995) and an important part of learning new practices (Dewey, 1963/1938; Grouws & Schultz, 1996; Silver & Stein, 1996). The lack of collaboration among peers could result in a lack of continued growth and even a regression to previous practices not aligned with standards-based practices.

Role of Professional Development

An important finding of this study is the apparent relationship between extent of involvement in the process of implementation and related professional development and the extent to which teachers engaged in standards-based instructional strategies. With

those teachers that were deeply involved in the selection process and professional development related to the curricula, the instructional philosophy on which the curricula is based is evident in their teaching. On the other hand, where teachers use curricula without a personal investment and/or professional development they tend to adopt their own style of teaching.

Consider the six case study teachers. One teacher from Galesburg and two teachers from Brookdale were involved in all professional development and all parts of the implementation process. While teaching styles differed, each of these teachers style was similar in that they allowed students to learn through discovery. In addition, all three teachers involved students in discussing their multiple strategies. The classroom environment had a focus on process, not just solutions. Of the six classrooms studied, only these three classes used problems as a catalyst for classroom discussion and not as homework to be graded.

One of the case study teachers from each district were involved in part of the implementation process and they interpreted the intended instructional practices of the respective curriculum similarly. Both reduced the amount they lectured; however, both fronted each day's investigation with "background information" that presented the "key concepts" to students. One case study teacher did not participate in the selection or professional development. She noted the differences in the text over other textbooks she

had seen, but did not describe or demonstrate any changes in her instructional practices. She still gave direct instruction over the topic that lasted for most of the hour.

In these six cases, decisions regarding what to allow students to discover through investigations and what to explain through direct instruction seemed to relate to the extent of their involvement in the entire implementation process. The nature of questioning in the classroom also varied with the extent of involvement, with those having been involved throughout the professional development activities allowing much more student dialogue and student-generated solutions. In these six cases, the level of involvement in the district implementation had a great impact on instructional decisions they made in their classrooms.

Need for Skill Development

Regardless of their experience with the district process of implementation, all teachers made decisions related to the amount of skill development that their students needed. All teachers contemplated the role of practice and procedural knowledge and to varying degrees supplemented the standards-based curriculum with skill development. This may have been in the form of daily warm-ups or taking a week or more between investigations to develop a skill. The amount of supplemental skill practice was more prevalent at Galesburg. This may have been due to the parental pressures in that district to have traditional skill work as homework.

The difference in the amount of supplemental skill practice that was used may also be related to collaboration. In Brooksdale, teachers reported that colleagues convinced them they didn't need to supplement the curriculum much and they trusted this advice. In Galesburg, the amount of supplementing varied by teacher. A case study teacher new to the district supplemented extensively, having little contact with colleagues that had prior experience and professional development with *MATH Themes*.

Discussion

Both district-level and teacher-level considerations are important in the implementation of standards-based middle school mathematics curriculum. Teacher decision-making is affected by district-level considerations, such as influence of parents and the extent and nature of collaboration with other teachers. Teachers in this study worried about reactions from parents. It appears that concerns of very vocal parents, and not necessarily a majority of parents, strongly influenced administrators and subsequently teachers. Teachers were able to recall with clarity instances when parents criticized an innovation in the district's recent past. Galesburg teachers, who described their parents as satisfied with a more traditional curriculum and upset about the difficulty of the new program, responded to parent wishes by significantly reducing homework and by offering a parent's night to respond to parental concerns. Brooksdale teachers described their parents as demanding a more challenging curriculum and they offered a number of parent nights to inform parents of the richness of the mathematics in the

curriculum. It is difficult to ascertain whether the expectations of parents were altered by the parent nights, or whether the parent nights were planned or skipped because of already existing expectations. It is important to note though, that parent expectations vary in different communities and district efforts to build parental support need to address the specific expectations and wishes of their parent community.

There are two arguments presented here for involving all teachers in decision-making and professional development prior to and during implementation of standards-based curriculum. One is that teachers learn the philosophy and techniques associated with the innovation and therefore are more informed as they implement the curriculum. In this study, the three teachers involved throughout the process applied standards-based instructional techniques to a higher degree than the other three. Use of standards-based practices decreased with decreasing participation in the decision-making process and professional development associated with the new curriculum. Secondly, during professional development, teachers were able to collaborate with their colleagues and develop a network that sustained their efforts. The collaboration supported teachers as they used new materials and employed new instructional techniques. On the other hand, the lack of collaboration in Galesburg resulted in a lack of continued growth and even regression to previous practices that did not align with standards-based practices. To implement *and* sustain a curriculum reform effort, teachers need to be involved in all parts of the process.

Another factor influencing curriculum reform in this study was teacher turnover. In particular, how does a district bring a new teacher into the standards-based environment and develop the relationships with colleagues to support the faithful use of the curriculum? As described in Galesburg, the new arrivals used more traditional instructional approaches and supplemented with more skill practice than their colleagues that had been involved in the implementation process. Attention must be given to understanding how to bring new arrivals into the practices of their more experienced colleagues. Implicit in this issue is the need to establish worthwhile collaborative relationships with colleagues that have used the curriculum. Establishing collegial support may be a necessary, but not sufficient, condition for new teachers to develop standards-based practices. As noted earlier, the teachers involved in the full professional development experience had a philosophical orientation that aligned with standards-based practices and their classrooms appeared to be more student-oriented. Conversely, the new arrivals, even when they were mentored, were more likely to transform the standards-based curriculum to traditional instructional practices. New arrivals need to have the opportunity to develop a philosophical base that aligns with the *Standards* in order to reform their beliefs and ultimately their teaching style.

Summary

The decision to implement standards-based mathematics curriculum involves varying issues and people within the context of the school system. More than sixty years ago, Dewey (1938) articulated the problem of teachers reforming within systems:

What is the place and meaning of subject-matter and of organization *within* experience?...When external control is rejected, the problem becomes that of finding the factors of control that are inherent within experience....The solution to this problem requires a well thought-out philosophy of the social factors that operate in the constitution of individual experience."

Some factors, such as educating parents and community, the appropriate level of skill development in a curriculum, and the need to be supported by colleagues are common across settings. Turnover, personality matches, administrative support can vary significantly from place to place. Teachers do respond to the needs of their individual settings. They react to the input of parents and administrators, as well as teachers that they respect. Their practices are influenced in part by external people and events.

Teachers are also influenced by their own perceptions, prior experiences and the professional development or interactions in which they participate. It was noted in Galesburg that the teachers who were involved in the entire process of change described a number of reasons for implementing standards-based mathematics curriculum, both internal and external, while those that had not participated throughout the process had fewer and externally motivated reasons (e.g., change in state testing). Without professional development and involvement in the decision-making, teachers may not be

internally motivated to change their practices. In this case, it is likely their practices will remain largely unchanged, even with the existence of a curriculum that supports standards-based practices. Collaboration increases teachers' opportunities to learn and to change. It also requires building a relationship with colleagues that requires time and shared experiences. After a professional development experience, teachers continue to make decisions regarding their curriculum and instruction. If the decision-making involves interaction with colleagues who support and challenge a teacher's thinking about teaching then he/she will continue to adjust their practices.

Implementing standards-based mathematics curriculum throughout a system is a complex process. The existence of a standards-based text supports teachers that want to and know how to implement standards-based practices, facilitating their efforts to change their teaching. The texts alone, however, do not result in different teaching, capable of being adapted to more traditional practices. Regardless of teachers' instructional practices, new curricula do, by their existence, solicit attention from stakeholders in the community. Educators must ensure that teachers receive both significant development to effectively implement a curriculum within their classrooms, and strategies for managing the peripheral factors of the school district that ultimately impact their implementation.

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